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An Historical Overview of Botany Education in American High Schools

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Old botany textbooks hold a strange attraction for me. Their engravings and technical botanical vocabulary make me think of a time when one could spend a pleasant afternoon dissecting flowers, analyzing seed pods, and marveling at simple plant adaptations. So, over the years I've collected a few dozen botany textbooks published between 1820 and 1930, and wonder, as I turn the pages, what it was like to study botany in high school so long ago.

During my summer botany workshop for school teachers, I always bring in a selection of these historic texts for the teachers to look at. They are amazed. They cannot imagine covering 450 pages of plant biology in one year! They tell me they are lucky if they have a week to cover photosynthesis and that botany is not an important part of the New York State Regents Living Environment curriculum.

But just a little over 100 years ago, nearly all high-school students studied botany for a full year using textbooks authored by internationally famous botanists, like Asa Gray and Liberty Hyde Bailey. I wanted to understand this, so I enrolled in a graduate level course in the History and Philosophy of Science Education at the State University of New York at Stony Brook. This is the paper that I wrote for the course.

Methods

In this study, I made use of four different kinds of resources. Scholarly reviews of the history of science education provided me with a framework (DeBoer 1991; Hershey 1996; Hurd 1961; Stout 1921; Tolley 2003). Contemporary published reports of committees and policy papers established the scope and intent of proposed reforms (National Education Association 1893; National Research Council 1996; Persing 1924). Articles written by contemporary botanists and educators gave insight into their reactions to the proposed reforms (Beal 1907; Ganong 1910a; Hershey 1996; Hughes 1919; Newcombe 1899). Finally, botanical

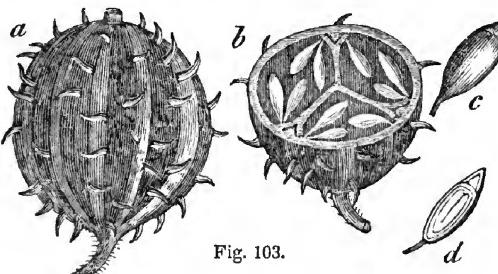


Figure 1. Engraving of a pepo, a regular monocephalous fruit with radiating placenta, of *Cucumis anguria* spiny cucumber (Phelps 1829).

textbooks gave an overview of the botany curriculum of the day (Bailey and Coleman 1908; Bergen 1896; Ganong 1910b; Gray 1857; Harrington 1880; Phelps 1829).

I chose ten botanical topics and laboratory activities and conducted a meta-analysis of textbooks to determine when these topics were included in the high-school curriculum (Table 1). A search for key vocabulary terms in the earlier textbooks was accomplished through Google Books.

Botany Education in American High Schools

American science education has gone through many changes since 1800, some driven by economic and demographic forces, and others by advances in scientific knowledge and technology. And some changes have been in response to reports and published recommendations of a series of educational policy committees that were formed to address a perceived

crisis in science education. I've looked at botany education in each of five distinct time periods, as it was influenced by some of these forces.

Female Academies: 1800 to 1860

Botany was an important part of the high-school curriculum from as early as 1800. It has been documented that in Pennsylvania and North Carolina, nearly 40% of female schools offered a course in botany before 1840 (Tolley 2003). The first widely used American high-school botany textbook, *Familiar Lectures on Botany* (Phelps 1829), was written by a woman, Almira Hart Lincoln Phelps, and it was so popular that over 40 years, it was reprinted 39 times (Rudolph 1984). "Mrs. Lincoln's Botany," as it was known, covered the topics of plant morphology, and classification (Figure 1). If the appearance of technical terms is any measure, the depth of course content is comparable to that of a modern college-level plant morphology course: the term silique, described as a bivalved pericarp, appears 19 times, or once on every 22 pages, for example.

(Continued on pg 3)

Long Island Botanical Society

Founded: 1986

Incorporated: 1989

The Long Island Botanical Society is dedicated to the promotion of field botany and a greater understanding of the plants that grow wild on Long Island, New York.

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Society News

Tidal Marshes of Long Island, New York has been published by LIBS and the Torrey Botanical Society and is available for purchase. This publication presents the most current research on Long Island's tidal marshes by the region's leading scientists and environmental law experts. Controversial tidal marsh "restoration and management" strategies and programs, like Open Marsh Water Management (OMWM), are analyzed and discussed. Human and natural impacts on salt marshes are presented as well as benign methods of healing salt marshes from the scars of mosquito ditches.

This hardcover volume includes 13 peer-reviewed articles by 18 authors, 171 pages with more than 200 color images, and an original pullout color map of L.I. (11" x 28"). The cost is \$40 for LIBS members and can be picked up at monthly meetings or ordered by contacting Eric Lamont via email (elamont@optonline.net). There is a \$6.50 charge for postage and handling.

LIBS T-shirts & Sweat-shirts are once again available for a limited time. They can be picked-up at monthly meetings. The cost is \$15 for T-shirts and \$25 for Sweat-shirts. For more information, contact Mary Laura Lamont at 631-722-5542.

LIBS Flora Committee is finalizing *Atlas of the Vascular Plants of Long Island, New York*, and is seeking funds for publication. All contributors will be acknowledged in the final publication. To make a contribution, make check payable to LIBS and mail to: Carol Johnston, Treasurer, 347 Duck Pond Road, Locust Valley, NY 11560.

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NOTE:

Membership renewals are due in January



ANNOUNCEMENT

The Long Island Native Grass Initiative (LINGI) presents its first annual Long Island Native Plant Symposium at Suffolk Community College in Riverhead on March 11, 2011. Contact Polly Weigand 631-727-2315 PollyW@suffolkcountyny.gov

(Cont. from page 1)

According to Mrs. Phelps, “The study of Botany seems peculiarly adapted to females: the objects of its investigation are beautiful and delicate; -- its pursuits, leading to exercise in the open air, are conducive to health and cheerfulness” (Phelps 1829). But although Mrs. Phelps recommended field work to her female students, it was, more often, the students at nearby boys’ schools who made excursions to “the borders of precipices, the sides of mountains, and the depths of the forest” to collect plants for the girls’ herbaria. Botany was taught in only 4% of boys’ schools at that time.

“Gray’s Botany” by Rote: 1860 to 1900

Between 1860 and 1900, most high schools offered at least a half-year course in botany (Stout 1921), usually during the second year of high school (10th grade). It should be remembered that in America at that time, less than 5% of the adolescent population attended high school.

The botany curriculum was based upon a text known as “Gray’s Botany” which was written by America’s preeminent botanist, Asa Gray. *Botany for Young People and Common Schools: How Plants Grow, A Simple Introduction to Structural Botany* (Gray 1858) covered topics of basic plant structure and morphology. This small textbook of just over 200 pages is an abridged version of an earlier work entitled *First Lessons in Botany* (Gray 1857). This simpler, more basic text was apparently the version in common use (Stout 1921) which explains why it is now so widely available in the antiquarian book market.

Whatever text was used, classroom lessons were, for the most part, taught by the rote method used to teach the classics. Text was presented as numbered paragraphs that students were to read in turn and to later memorize and recite. As with “Mrs. Lincoln’s Botany,” botanical content was dense: in one short chapter entitled “The Fruit,” students learned to distinguish between berries, pomes and pepos and were expected to master more than 20 technical terms including akene, silique, and pappus.

“Gray’s Botany” included, at the back, a “popular flora” of more than 500 species of common plants along with descriptions, illustrations, and a dichotomous key which students learned to use for plant identification. Non-vascular plants were not mentioned, nor were the nascent fields of plant physiology, ecology, genetics, and evolution. The economic value of plants for human food, fuel and materials was treated as a topic of some importance.

The correct method for preparing an herbarium, a labeled and mounted collection of dried plant specimens, was presented in the advanced text (Gray 1857), and students were instructed in the use of a dissecting microscope to observe morphology of smaller flowers.

A popular approach to botany instruction during the 19th century was known as “plant analysis.” Students were assigned to collect and study a certain number of locally available plants, to record their observations on standardized data forms, and to identify them using the dichotomous keys in the popular flora. One text used for this purpose (Harrington 1880) is a “little book of blanks” with a two-page form for each of 50 plants to be analyzed, including 10 composites and six grasses. Students were to draw floral diagrams and to use correct botanical terminology to describe fruit type, leaf shape, and other morphological features. The author states, “Botany can be taught as thoroughly and be made as efficient a means of mental discipline as the classics or mathematics. It is even superior to them in the training it gives to the powers of observation and critical judgment.”

Although popular among teachers, plant analysis was generally disliked by both students, who found it to be tedious, and botanists, who found it to be without scientific merit. By the end of the century the method of plant analysis had “brought the whole science of botany into contempt” (Newcombe 1899). Describing and identifying plants, while a “pleasant diversion,” could not take the place of laboratory study “including the elements of structure, development, relationship, and physiology.”

The Golden Age of Botany Teaching: 1900 to 1910

Towards the end of the 19th century, as America’s population expanded and became more urbanized, the National Educational Association appointed a committee to address the lack of standards for pre-college education. The Report of the Committee of Ten (National Education Association 1893) included the recommendation that a full year of botany or zoology be offered in high school. The sub-committee on natural history, composed of botanists and zoologists, were adamant that either botany or zoology be offered, but not a combination of the two (Sheppard and Robbins 2006, 2007).

The early 1900s has been called “Golden Age of Botany Teaching” (Hershey 1996). Most high-school students took at least one semester of botany. Examinations in botany were offered by the New York State Board of Regents (Figure 2) and by the College Board. New textbooks proliferated, and one botanist complained in a letter to the journal Science, “it is a pretty dull week when some one does not put out a new botanical textbook” (Beal 1907).

“Study nature, not books” was the motto of the nature study movement of elementary school science reform that swept the country around that time (Kohlstedt 2010). Led, in part, by botanist Liberty Hyde Bailey, this was a new approach to schooling that paved the way for laboratory instruction, inquiry learning, and the school garden movement.

(Cont. on page 4)

Figure 2. 1894 Regents Botany Examination.

36
University of the State of New York
Examination Department
118th examination
BOTANY

Tuesday, January 23, 1894 — 9:15 a. m. to 12:15 p. m., only

100 credits, necessary to pass, 75

Answer any 10 questions but no more. If more than 10 questions are answered only the first 10 of these answers will be considered. Each complete answer will receive 10 credits.

- 1 Define protoplasm, plumule, rhizome, glume, shrub.
- 2 What are the four stages of plant growth? Briefly describe each stage.
- 3 Whence does the plant obtain food or material for its growth during each period of its life?
- 4 Describe primary roots. What are secondary roots? Give examples of each.
- 5 Briefly describe the mode of propagating plants by (a) scions, (b) slips, (c) cuttings, (d) stolons, (e) runners. Name a plant illustrating each method.
- 6 Describe three arrangements of the leaves on the stem and give examples of each.
- 7 Represent by diagrams any three of the following leaf forms: (a) lanceolate, (b) pinnately lobed, (c) palmately three-cleft, (d) pinnately compound, (e) palmately compound with five leaflets.
- 8 To what kind of inflorescence does each of the following belong: raceme, spike, cyme, panicle, head? Name a plant illustrating each.
- 9 What family or order of plants includes shepherd's purse? Give the chief characteristics of the order and name three other plants of the same order.
- 10 To what family or order of plants does the white daisy belong? Give the chief characteristics of this plant and name three other plants of the same order.
- 11 Name and briefly describe two systems of classification of plants.
- 12 What is the meaning and object of botanic analysis? Illustrate your answer.
- 13 Describe wheat and red clover as to root, stem, leaf, flower, fruit. Name the order to which each belongs.
- 14 Mention five plants serviceable to man for (a) food, (b) clothing, (c) shelter.
- 15 Mention three kinds of shade trees found in your locality and five kinds of trees common in the forests of New York state.

(Cont. from page 3)

The most widely used botany textbook during that time, *Elements of Botany* (Bergen 1896), was written by a Boston high-school teacher. It featured a laboratory approach to all subjects including, for example, three pages on “carbon fixation” (i.e., photosynthesis). With the compound microscope recently available for student use, and a growing interest in the new topic of evolution, the content of the typical high-school botany

course grew to include the study of algae, fungi, mosses and other non-vascular plants. The concept of alternation of generations was presented, and plant anatomical features were observed, drawn, and labeled. The popular flora remained in its traditional place at the back of the book, but was reduced to 50 pages covering fewer than 250 spring flowers of the Northeast.

This laboratory approach to instruction had become a new and exciting educational trend. Educational supply companies emerged to manufacture and market such specialized laboratory equipment as the device illustrated in Figure 3, which was needed for one of more than 10 experiments demonstrating photosynthesis that appeared in one botany teacher training manual (Ganong 1910b).

But soon the over-reliance upon equipment for botany laboratory instruction became an obstacle. In his presidential address to the Botanical Society of America in 1909, Ganong admonishes, “It is much easier for us Americans to obtain great laboratories and fine equipment than to make good use of them afterwards” (Ganong 1910a). He goes on to mention that laboratories are expensive and that teachers rarely have proper training to use this equipment. Concerning the teaching of the local flora and the practical aspects of field botany and plant identification, Ganong noted that few universities provided adequate opportunities for pre-service teachers to obtain useful experience.

The Rise of General Biology 1910-1930

A new course, “General Biology,” was created when the New York State Board of Regents published a generalized syllabus for a year-long course combining the three subjects of botany, zoology, and human physiology; and in 1906, began offering a Regents Examination. The popularity of this new approach was such that by 1928 more than 13% of high-school students were enrolled in biology while only 1.6% were enrolled in botany (Hershey 1996).

A First Course in Biology (Bailey and Coleman 1908), a popular text of that time, was really three separate volumes; botany, zoology and human physiology; bound together. Noted Cornell botanist Liberty Hyde Bailey authored the section on botany. It began with an activity investigating the natural variation among living plants followed by chapters on adaptation, natural selection, and ecology. The traditional terminology-dense topics of descriptive morphology, e.g. fruit structure, were still present, but there was a new emphasis on function, with a discussion of modes of seed dissemination for example.

In the spring of 1919, a conference on Botanical Education in the Secondary Schools was held by the Torrey Botanical Club in New York. Among the speakers were two high-school teachers who spoke about the botanical content of the new general biology curriculum (Hughes 1919; King 1919), suggesting that it be made more practical and concrete. They complained that, with the newly required courses in general science and community civics, there was insufficient time in the school day in which to offer biology. And since colleges trained teachers in either botany or zoology, high-school general biology was often, in reality, “botany taught by a zoologist” (Hershey 1996; Nichols 1919).

University botanists, aware that their discipline was fast disappearing from high schools, came forth with solutions. One botanist noted the importance of taking into account the abilities and interests of the high-school student (Caldwell 1907). The tension between pure and applied science was also blamed for the decline of botany: “The agriculturist has crept in while the botanist slept and has stolen the very soul of his subject” (Pool 1919).

Much was written about the problem of “college-style courses” in high-school biology (DeBoer 1991) with lectures and exhaustive and tedious laboratories. In response, the consolidated high-school biology course was intended to bring a more practical, problem-solving approach (Hurd 1961) and teachers were encouraged to go on field trips to zoos and botanical gardens. One botanist warned that high-school botany courses must no longer be watered down college courses and, as instructors we must “shelve some of our microscopes, ...put away some of our pet botanical cadavers, and get down to the living, growing producing plant...” (Pool 1919).

The period following World War I brought about waves of educational reform with committees created to evaluate and report on every aspect of the American education system. The Committee for Reorganization of the Biological Sciences produced an outline for a 10th grade general biology course (Persing 1924) that became widely read and followed. Eleven major ideas were chosen as the basis for the reorganized general biology course, for example, “1. There is a fundamental resemblance between plants and animals (protoplasm and cell structure).” and “2. The work of higher plants has led to a differentiation of parts and a division of labor among cells (plant structure and adaptation to specific environments).” There was an emphasis on topics of social value and interest, and there was no time left for plant morphology, or a study of the local flora, or plant analysis.

Biology Education--1930 to the present

In 1930, the Botany Editor of the journal School Science & Mathematics reported a decline in the submission of botany articles and issued an appeal: “Are botany teachers doing no

thinking?” he asked (Whitney 1930). Unfortunately, by that time, there were actually not many teachers of botany left to answer his call. For sometime during the 1930s, botany ceased to be taught as a course separate from general biology. By 1936, with textbooks no longer in print, the College Board dropped the botany examination altogether.



Figure 3. A Simple Normal Light Screen (Ganong 1910b). This laboratory device allows light to hit only that area of the leaf within the star-shaped window, where photosynthesis will occur and starch will accumulate.

In the decades that followed, general biology grew into the most universally offered course in American high schools, and is now frequently a requirement for graduation. In the modern biology curriculum, unifying concepts, for example cell biology, ecology and evolution, are applied to both plant and animal kingdoms. As scientific knowledge advances, and topics have become more complicated, teachers are challenged to engage student interest. This has indirectly resulted in further loss of botanical content as educators find animal, especially human, biology to be more dynamic and interesting.

In the 1940s, a series of educational reform committees promoted this practical and anthropocentric bias in biology education (Hurd 1961) and emphasized the topics of human health and physiology, heredity and conservation, over less interesting and compelling topics of scientific method and photosynthesis. World War II brought a briefly renewed interest in medicinal and economically useful plants and in gardening, however.

In the 1950s, the National Science Foundation took leadership in addressing what was perceived as a crisis in science education. The Biological Science Curriculum Study was undertaken, resulting in the publication of a series of textbooks and films covering specific topics in modern biology (Rudolph 2002). This successful program still exists, but again, includes reduced botanical content.

(Cont. on page 6)

(Cont. from page 5)

	Phelps, 1826	Gray, 1857, 1858	Bergen, 1896	Bailey and Coleman, 1908	Biological Science Curriculum Study 1960 to 1970	New York State Regents Living Environment 2010
Collect, identify, and preserve an herbarium of 25 local plants	yes	yes	yes	no	no	no
Go on a field trip to a nature preserve	yes	yes	yes	yes	yes	no
Use botanical terminology to describe fruit types	yes	yes	yes	yes	no	no
View the anatomy of a plant stem with a microscope	yes	yes	yes	yes	yes	yes
Draw a filamentous alga, e.g. <i>Spirogyra</i>	no	no	yes	yes	yes	no
Conduct laboratory experiments to demonstrate photosynthesis	no	no	yes	yes	yes	no
Study a diagram showing plant gametophytes and alternation of generations	no	no	yes	yes	yes	no
Draw a Punnett square to show inheritance of flower color	--	--	--	--	yes	no
Read about plant ecological succession	--	--	no	yes	yes	yes
Learn where rubber and cotton come from	yes	yes	no	yes	yes	no

The National Science Education Standards is a document, created during the 1990s, that now guides the standardization of the scope of science curricula across the country (National Research Council 1996). Unfortunately, the botany content of this important document is minimal and sometimes erroneous (Hershey 2005).

Because many general biological principles apply to both plants and animals, it is no surprise that biology curricula favor animal examples. Illustrations featuring the most exciting and interesting subjects, especially those large “charismatic macrofauna” far outweigh plant illustrations in nationally published science textbooks (Schussler et al. 2010; Uno 1994).

Since the New York State Board of Regents replaced the Biology curriculum with the Living Environment curriculum about 10 years ago, the botanical content in New York high schools has been further reduced to the point that any student who omitted the answer to every plant-related question on the Living Environment Regents Examination could still receive a passing grade of 80%.

Discussion

It seems to me that there are several forces that have led to the decline of botany as a subject in high schools.

1) The rise of modern biology. Two hundred years ago, botanists worked primarily in the fields of morphology and taxonomy, naming and describing all the newly discovered natural wonders of the plant world. Over time, with new discoveries, the unifying concepts of general biology developed, and it became important that students be exposed to molecular and cellular biology, ecology, and evolution. General biology was much more efficient for schools than separate courses in botany and zoology and fit into the educational philosophy of the time.

2) “Animal chauvinism.” This is our preference for studying organisms most like ourselves (Hershey 2005). Educators and textbook authors have neglected plants when presenting the unifying concepts of modern biology, in order to better motivate and engage students.

3) Teacher preparation. Whether it was the challenge of using new laboratory equipment in 1910 or the lack of familiarity with the local flora in 2010, teachers who are uncomfortable with botanical science will avoid teaching it, and will fail to adapt to changes within the field.

4) Too much like Latin. I was unable to find any supporting documentation for this, but throughout this paper I have tried to illustrate this idea: botany as a subject, like Latin, has had a reputation for being difficult and tedious. Although the vocabulary of botany, which is largely based on Latin and Greek, would have reinforced and supported the learning of classical languages during the 19th century, it has no relevance to modern curricula.

5) Too much busywork. The method of plant analysis enabled teachers, with minimal training or effort, to engage students in an activity with a tangible outcome, the student herbarium. Although it had given botany such a bad name, plant analysis remained a popular activity well into the 1940s.

6) Urbanization and homogenization. I believe that biology teachers today would cover more botany if they had the necessary local resources. But because the educational publishing industry responds to national needs, high-school biology texts that include regional vegetation are non-existent. Teachers who have studied the local flora in college may find themselves teaching in a community in another part of the country where, if they wish to learn the local flora, they are on their own.

Conclusion

Contemporary botanists are well aware of the “plant blindness” that pervades pre-college biology education (Hershey 2005; Uno 1994) and have suggested remedies. Recently, with the support of the National Science Foundation, the two major botanical professional organizations, the Botanical Society of America and the Association of Plant Biologists, have undertaken ambitious projects to improve botany education in public schools. So perhaps we can look forward to a revival of botany education in the near future.

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Long Island Botanical Society
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Page 8

Long Island Botanical Society Vol. 21 No.1

UPCOMING PROGRAMS

January and February: No meeting!

March 8, 2011* Tuesday, 7:30 PM
Cesar Castillo: “Cretaceous Plant Fossils of Long Island.” This talk will cover some of the common types of plant fossils from the Cretaceous, including micro and macro plant fossils, their importance, and the description of two plant fossils from the Long Island Cretaceous. It will also include some of the geological history of the fossil location at Caumsett State Park. Cesar has recently completed his Masters in Biology at CUNY (Queens College) where he concentrated on Botany, and he has been working on the fossils of Long Island for three years.

*Location: Bill Paterson Nature Center,
Muttontown Preserve, East Norwich*

April 12, 2011* Tuesday, 7:30 PM
Larry Liddle: “The Seaweeds of Lake Montauk.” This study is part of a larger initiative of the East Hampton Town Department of Natural Resources to prepare a complete inventory of the bios of the lake which has been open to the bay since the late 1920s. A comparison of the seaweeds of the lake will be made with other East End sites. Larry is Professor Emeritus in Marine Biology from Long Island University.

Location: Museum of Long Island Natural Sciences, Earth and Space Science Building, Gil Hanson Room (Room 123), SUNY at Stony Brook, Stony Brook

* Refreshments and informal talk begin at 7:30 p.m.
Formal meeting starts at 8:00 p.m.
Directions to Muttontown or Stony Brook:
516-354-6506